Research on 3D Technology in Design Method of the Dental Orthodontic Brackets

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ABSTRACT

Through 3D technology, exploring a design and manufacture method of the orthodontic brackets with the characteristics of individuation, highly compact degree and high production rate. Methods: By the technology of 3D scanner and Reverse engineering, a new design and manufacturing technology of individual bracket was presented. Firstly, got the 3D scanning data of teeth and then transformed it into the dental CAD models by reverse technology. Secondly, designed customized bracket based on the CAD model. Finally, used 3D printing equipment of selective laser melting to manufacture brackets. Results: 3D technology can be used to design and produce personalized orthodontic brackets effectively. Conclusion: In the design and production of orthodontic brackets, 3D technology has more advantages than traditional design and production methods.¹

KEYWORDS

3D printing; Reverse Engineering; Orthodontic Brackets; Computer—Aided Design

INTRODUCTION

The wide application of 3D technology has promoted the rapid development of modern manufacturing industry, and got increasing attention from medical domain in recent years. By dint of Computer aided design and manufacturing technology, in

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In the designing period, it’s an effective method for 3D modeling using various modeling software platform. With the help of the 3D scanning technology obtaining the digital model directly is another efficient way. 3D printing technology is an emerging mode of manufacturing in the production phase besides of the traditional methods of production. Considering of the complex structure that traditional processing technology can’t meet the processing needs, 3D printing technology has great advantages.

Dental braces are devices used in orthodontics that align and straighten teeth and help position them with regard to a person's bite, while also aiming to improve dental health. Most orthodontic patients are children or adolescents, however, in recent years, more and more adults have also begun to seek orthodontic treatment. Currently the most widely used dental braces structures is a common metal bracket.

The traditional method of production can only produce a fixed type of dental braces. There are many drawbacks when selecting the type of dental braces. This article will be put forward a new type of dental brackets design and production methods based on 3D technology.

**BASIC STRUCTURE OF DENTAL BRACES AND OPERATIONAL PRINCIPLE WITH PROBLEMS IN PROCESSING**

**The Basic Structure of Dental Braces**

Dental braces are tools used to correct the position of the teeth. The main clinical manifestations of dental malformations are abnormalities in the position and posture of the teeth and the consequent dislocation of the occlusion relationship and the imbalance of the facial features. Orthodontic traction is a key factor in tooth movement during orthodontics, which devices for dental appliances. In order to adjust the teeth to the proper position, it’s important to understand the structure and working principle of the dental braces before analyzing the way the dental braces to correct teeth.

The basic structure of metal dental braces is divided into brackets and arch wire. The material of arch wire is nitinol, we can choose different sizes according to the different needs of patients. The arch wire is embedded in the groove of the bracket and fixed by a steel wire sleeved on the bracket wing. The soleplate of the bracket is stuck on the tooth, the orthodontic traction force transmitted from the arch wire, so that the tooth is displaced and steered to correct position completely.

**Operational Principle of Dental Braces**

There are two major tasks during the orthodontic treatment: The first is the adjustment, that is adjusting the position of the teeth to, making the misplaced teeth return to normal position; the second is to adjust posture, that is, the three-dimensional posture of teeth to be adjusted so that an abnormally shaped tooth
regains normal three-dimensional posture to reach normal standards while improving face shape. The adjustment phase requires a large clearance between the bracket and the arch wire, as well as a small friction. Calm stage bracket and arch wire clearance between the small and large friction. This requires dental braces to achieve different needs in different orthodontic phases.


Figure 1. Metal bracket.

First of all, during the tooth positioning phase, the point contact of the arch wire and the groove of the bracket slot is used to correct the dislocation of the orthodontic and complete the tooth flattening quickly. In the phase of posture, The orthodontic wires were inserted into the groove of the brackets and were in contact with the brackets and grooves. At the same time, the dental braces use the elastic force of the self-locking lid on the arch wire into the bracket groove. The friction of arch wire and bracket groove is large, which can accurately control the three-dimensional teeth posture. The doctor can control the orthodontic process by changing the traction applied to the brackets by selecting different diameters of wire. Only fully fit the brackets on the tooth surface, the traction is suitable, so as to achieve the best therapeutic effect, see in fig 2. Brackets on both sides of the tooth are responsible for securing both ends of the arch wire and exerting traction on the arch wire.

Problems During The Dental Braces Design

In order to meet the needs of different patients, each patient needs a different treatment of the dental tray bracket tailored to personalize. In traditional orthodontic clinical work, it uses gypsum model records the actual shape of the patient's teeth, and the doctor choose the right dental braces through the plaster model. In the production, the traditional brackets CNC machine tool cutting the overall production. Firstly, the stainless steel block is cut by wire cutting tool, and the bracket wing and groove are generated. Then, the CNC machine is used to process the bottom plate by point by point milling, and the individual bracket is formed.

The traditional design and processing methods have the following problems:

First, the method of using gypsum to make a model has long production cycle, high cost and low accuracy. Furthermore, during the process of making the gypsum
model, the gypsum needs to be put in the mouth of the patient, which may cause discomfort to the patient.

Second, The traditional method of bracket processing is batch production. Faced with different patients and different stages of tooth adjustment, mass production of dental braces is difficult to fully meet the needs of patients to modify or replace and use unsuitable brackets, it is uneasy to teeth Corrected to the ideal location, thus affecting the treatment effect.

Third, the bracket floor needs to completely fit the tooth surface, while the tooth surface is a complex 3D surface that increases the machining difficulty. In the meantime, after the traditional processing method is used to finish the processing of the bottom plate of the bracket, in order to facilitate the bonding of the bracket and the tooth surface, the surface of the bottom plate needs to be sandblasted and micro-etched so as to increase the manufacturing process and increase the cost.

As a result, there is a need to find a new way of production that is able to adapt to different patient needs while meeting the machining accuracy requirements with the lowest possible cost.

DENTAL BRACES DESIGNS BASED ON 3D TECHNOLOGY

3D Scan The Outer Surface of The Tooth

In recent years, 3D technology is gradually applied to clinical dental, so professionals consider the establishment of three-dimensional digital model of teeth instead of the traditional plaster model. There are many ways to obtain the digitized model of the tooth. At present, the CT scan method, the tomography method and the 3D scanning method are commonly used. The 3D scanning method obtains the 3D point cloud data of the patient's tooth surface directly using a 3D scanner with the accuracy of less than 20μm, which fully meets the clinical requirements. At the same time, using of 3D scanning meets the individual needs of different patients. Compared with the establishment of plaster model, 3D scanning method is more convenient, safe and hygienic.
In addition to meeting the needs of different patients, dental braces made with 3D scanning can also be used for phased treatment. In different stages of treatment, besides of the location of the patient's teeth, the dental posture is not the same. After obtaining the three-dimensional digital model of the tooth, the dental model can be divided and the correction path can be planned to simulate the entire tooth correction process. In different stages of orthodontics, 3D models can be used to obtain dental models quickly enough to produce dental braces for different courses in time, which avoids the cumbersomeness of traditional modeling methods. Throughout the treatment process, patients simply follow the doctor's instructions, wear different dental braces in different courses, to maintain the effect of arch wire force.

**The Formation of 3D Tooth Model**

After the 3D point cloud data of the outer surface of the tooth is obtained by the 3D scanner, which needs to be further processed. The basic process includes removing noise, filling cavities, cross-section splicing and so on. Then it obtains three-dimensional continuous and complete data. The three-dimensional model data is stored in WRP format, which has the advantages of small file size and high precision, and facilitates post-production.

![3D model of metal bracket.](image)

Subsequently, the three-dimensional model of the tooth is matched to obtain the data of the denture bracket bottom plate surface. Based on the generated bracket bottom plate model, a suitable bracket size is selected to form a bracket model that meets the individual needs of the patient, finally the production is performed. The brackets produced in this way fit closely to the surface of the tooth, giving the tooth the optimum orthodontic traction to achieve the best results.
3D Printing --- Production of Dental Braces

Although the traditional processing technology can’t meet the processing needs of complex structures gradually, the use of 3D printing technology greatly improves the ability to produce complex structures.

The 3D printing braces are used by the laser sintering technology based on titanium alloy powder. Laser sintering method is a way using laser beams, through the layered scanning, selective sintering alloy powder, sintered through the layers to form a solid, after simple processing so that production can be used.

Using laser sintering Direct manufacturing technology to produce brackets, of which floor surface is accuracy, meeting the individual needs of patients. In order to facilitate the fitness of bracket floor and tooth surface, the traditional processing methods also need sandblasting and micro-etching the bottom surface of the plate, thus increasing the cost. By using of 3D printing technology, it can print out the required bracket directly on the bottom surface, achieving the same result with sandblasting or micro-etching, thereby enhancing the adhesion. This reduces a production process directly, speed up the production and reduce costs.

CONCLUSIONS

This paper introduces a dental braces design and production method based on 3D technology, compares the new braided design and production method with the traditional methods, and draws the following advantages:

(1) Personalization and high degree of confidentiality: By scanning the patient's teeth with 3D scanning technology, the patient's dental model can be conveniently and quickly drawn on the computer to match with the high density of the dental tray which meets the requirements of the patient’s personalized needs and makes them feel comfortable.

(2) Easy to replace and modify: the traditional processing methods can only be in accordance with different models of mass production, the use of further selection, the choice is limited. 3D printing technology can be customized directly to produce a personalized floor according to bracket bottom plate model generated by the tooth model, matching with teeth of different patients accurately.

(3) Fast production, high precision: After the scanning of the teeth, only with the brackets that fit the teeth of the patient can be put into production immediately, and the 3D printing technology has higher speed and accuracy in the processing of the bracket bottom plate.

To sum up, the design and production method of the dental mouthpiece based on 3D technology can make up for the shortcomings of poor adaptability, low conformity, low output and high processing difficulty of the traditional production methods. Compared with the traditional processing methods, 3D technology has a great advantage in the dental braces brackets production.
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